University of California, Berkeley
Physics 110B Fall 2004 (*Strovink*)

EXAMINATION 4

Directions: Do both problems, which have unequal weight. This is a closed-book closed-note exam except for Griffiths, Pedrotti, a copy of anything posted on the course web site, and anything in your own handwriting (not a Xerox of someone else's writing). Calculators are not needed, but you may use one if you wish. Laptops and palmtops should be turned off. Use a bluebook. Do not use scratch paper – otherwise you risk losing part credit. Show all your work. Cross out rather than erase any work that you wish the grader to ignore. Justify what you do. Express your answer in terms of the quantities specified in the problem. Box or circle your answer.

Problem 1. (35 points)
A monochromatic beam traveling in medium "0" is normally incident upon a substrate *"T"*. Two films ("1" and "2") are interposed between the two media, such that film 1 adjoins medium 0 and film 2 adjoins medium T. The refractive indices are frequency-independent and equal, respectively, to n_0, n_1, n_2, and n_T, with $n_0 \neq n_T$. You may assume that all materials are insulating and nonabsorbing, and that they all have the same magnetic permeability. Film "1" has thickness $\lambda_i/4$ (where λ_i is the wavelength of the beam in the particular material of which that film is made), while film "2" has thickness $\lambda_i/2$.

(**a**) (20 points)
Find a condition on n_0, n_1, n_2, and n_T that allows no light to be reflected. This need not be the most general condition – full credit goes to any solution that you show will work.

(**b**) (15 points)
Now the wavelength of the monochromatic beam is *tripled*, while both films retain their *same* physical thicknesses (in meters). Find a condition on n_0, n_1, n_2, and n_T that allows no light of the *original* wavelength to be reflected, and also allows no light of the *tripled* wavelength to be reflected.

Problem 2. (65 points)
Plane-wave natural (unpolarized) light of wavelength λ traveling in the $+\hat{z}$ direction is normally incident upon screen #1 at $z = 0$. Two long thin slits are cut in this screen at

$$x_1 = \pm\frac{d}{2}\ .$$

Screen #2 is located at $z = 2f$. A thin lens of focal length f is placed halfway between screen #1 and screen #2, at $z = f$. Fraunhofer conditions apply. A diffraction pattern is observed on screen #2.

(**a**) (15 points)
In terms of λ, d, and f, what is the distance Δx_2 between two adjacent irradiance maxima on screen #2?

(**b**) (15 points)
A pair of long thin slits is now cut in screen #2, at

$$x_2 = \pm\frac{\lambda f}{4d}\ .$$

A third screen (#3) is placed at $z = 4f$. A second thin lens of focal length f is placed halfway between screen #2 and screen #3, at $z = 3f$. Fraunhofer conditions continue to apply. A diffraction pattern is observed on screen #3. In terms of λ, d, and f, what is the distance Δx_3 between two adjacent irradiance maxima on screen #3?

(**c**) (20 points)
A right-hand circular polarizer is now placed

to cover the top slit of screen #1, and a left-hand circular polarizer is now placed to cover the bottom slit of screen #1. The polarizers are identical except for their handedness. Describe the *shape* (dependence on x_3) of the new irradiance pattern on screen #3.

(**d**) (15 points)
Screen #2 is now removed altogether (allowing all of the light to pass), and the polarizers in part (c) are removed as well. You may assume that Fraunhofer conditions continue to apply. Describe the *shape* (dependence on x_3) of the new irradiance pattern on screen #3.